Energy Efficiency Improvement for Natural Gas Liquids Direct-Splitter-Direct Sequence Fractionation Unit

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Abstract

The objective of this paper is to present the study and analysis of the energy saving improvement for the NGLs Direct-Splitter-Direct fractionation plant sequence by using driving force method. To perform the study and analysis, the energy efficient distillation columns (EEDCs) methodology is developed. Basically, the methodology consists of four hierarchical steps; Step 1: Existing Sequence Energy Analysis, Step 2: Optimal Sequence Determination, Step 3: Optimal Sequence Energy Analysis, and Step 4: Energy Comparison. The capability of this methodology is tested in designing an optimal energy efficient splitter sequence of NGLs fractionation unit. The results show that the maximum of 10.62 % energy reduction was able to achieve by changing the sequence suggested by the driving force method. It can be concluded that, the sequence determined by the driving force method is able to reduce energy used for a NGLs fractionation. All of this findings show that the methodology is able to design energy efficient for NGLs fractionation sequence in an easy, practical and systematic manner.

Keywords: Energy Efficient; Distillation Columns Sequence; Driving Force; Natural Gas Liquid.

1 Introduction

Once natural gas liquids (NGLs) have been separated from natural gas stream, they are further separated into their component parts, or fractions, using a distillation process known as fractionation. Distillation is the primary separation process widely used in the natural gas processing. NGLs normally have significantly greater value as separate marketable products that as part of the natural gas stream. Lighter NGL fractions, such as ethane, propane, and butanes, can be sold as fuel or feedstock to refineries and petrochemical plants, while the heavier fractions can be used as gasoline-blending stock. Although it has many advantages, the main drawback is its large energy requirement, which can significantly influence the overall plant profitability. Through applying proposed methodology in Figure 1, it is possible to make an early assumption on sequence of distillation column systems that is the best in terms of energy saving. Significant energy savings can be made through the use of distillation column employing the driving force [1] and energy integration [2] methods. The conventional existing distillation column can be used in the new NGLs fractionation design, however, only the configuration or sequence that needs to be changed.

Bek-Pederson and Gani [1] developed a systematic design and synthesis of distillation systems using a driving force based method. This method suggested that at the highest driving force, the separation becomes easiest due to the large difference in composition between the phases and therefore, the energy necessary to achieve the separation task at each individual distillation column is at a minimum. In distillation column, the driving force can be shown by facing distinction in composition of a component *i* between the vapour and liquid phase due to the difference of properties such as boiling point and vapour pressure of component *i* and the others. Besides that, Sobocan et. al. [5] also proposed a systematic synthesis of energy integrated distillation column systems which able to reduce external energy input of the distillation column systems. Through this method the utility consumption is minimized meanwhile the heat exchange between the ntegrated columns is maximized.

In this paper, the study and analysis of the energy saving improvement for the NGLs fractionation plant sequence by using driving force method without having any major modifications to the major separation units, is presented. There will be only modifications to the separation sequences based on the driving force results, which will reduce the energy requirement. To perform the study and analysis, the energy efficient NGLs fractionation plant sequence methodology is developed. Accordingly, the methodology consists of four hierarchical steps. In the first step, a simple and reliable short-cut method is used to simulate a base (existing) NGLs sequence. The energy used in the base sequence is taken as a reference. In the second stage, an optimal NGLs sequence is determined by using driving force method. All individual driving force curves is plotted and the optimal sequence is determined based on the plotted driving force curves. Then, by using a short-cut method, the new optimal sequence is simulated in step three, where the energy used in the optimal sequence is analyzed. Finally, the energy used in the optimal sequence is compared with the base sequence.

2 Methods

To perform the studies and analysis, the energy efficient NGLs fractionation plant methodology is developed [3]. Basically, the methodology consists of four hierarchical steps (see Figure 1).

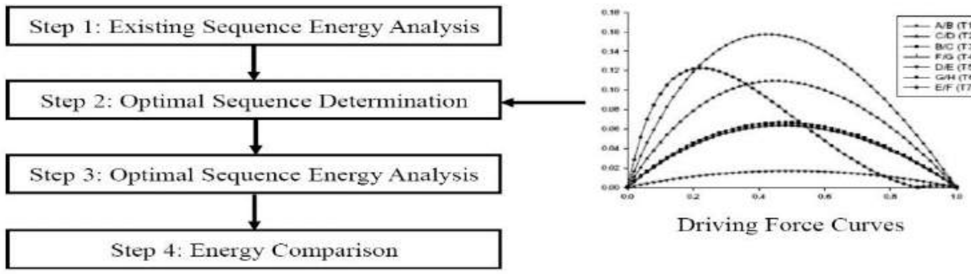

Figure 1: Energy efficient distillation columns sequence methodology [3]

In the first step, a simple and reliable short-cut method of process simulator (Aspen HYSYS) is used to simulate a base (existing) NGLs sequence. The energy used to recover individual fractions of the NGLs in the existing sequence is analyzed and taken as a reference. In the second stage, an optimal NGLs sequence is determined by using driving force method. All individual driving force curves is plotted and the optimal sequence is determined based on the plotted driving force curves. According to Bek-Pederson and Gani, the optimal sequence with the most energy efficient can be determined from the plotted driving force curves [4]. The first column should be the one with the largest value of the maximum driving force. Theoretically, the largest value of the maximum driving force means the easiest separation task with the minimum energy requirement. In addition, the lowest value of the maximum driving force means the most difficult separation task with the maximum energy requirement, which should be the last column in the sequence. Once the optimal sequence has been determined, the new optimal sequence is then simulated in step three using a simple and reliable short-cut method (using Aspen HYSYS), where the energy used in the optimal sequence is analyzed. Finally, the energy used in the optimal sequence is compared with the base sequence.

The capability of this methodology is tested in designing an optimal energy efficient splitter sequence of NGLs fractionation unit. The existing NGLs fractionation unit consists of nine compounds (methane, ethane, propane, i-butane, n-butane, i-pentane, n-pentane, n-hexane, n-heptane) with eight direct splitter sequence (see Figure 2) was simulated using a simple and reliable short-cut method within Aspen HYSYS environment.

3 Discussions

3.1 Existing Sequence Energy Analysis

The existing NGLs fractionation process shown in Figure 2 was simulated using a simple a reliable short-cut method within Aspen HYSYS environment. A total of 137.50 MW energy used to achieve 99.9% of product recovery.

3.2 Optimal Sequence Determination

A new optimal sequence was determined by driving force method. All individual driving force curves was plotted as shown in Figure 3, and the optimal sequence was determined based on the plotted driving force curves. The new optimal sequence based on the driving force method is shown in Figure 4.

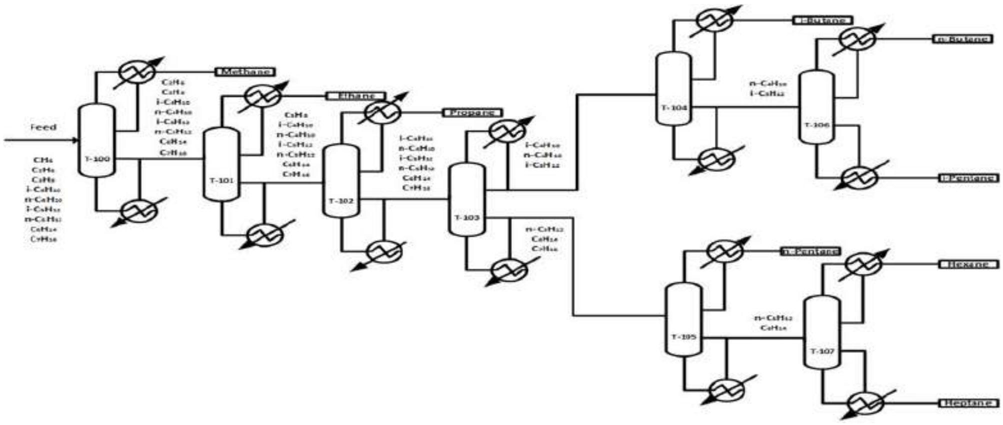

Figure 2: Flow sheet illustrating the existing direct-splitter-direct sequence of NGLs fractionation process

3.3 Optimal Sequence Energy Analysis

A new optimal sequence determined by driving force method (see Figure 4) was simulated by using a short-cut method within Aspen HYSYS environment where a total of 122.9 MW of energy was used of the same product recovery.

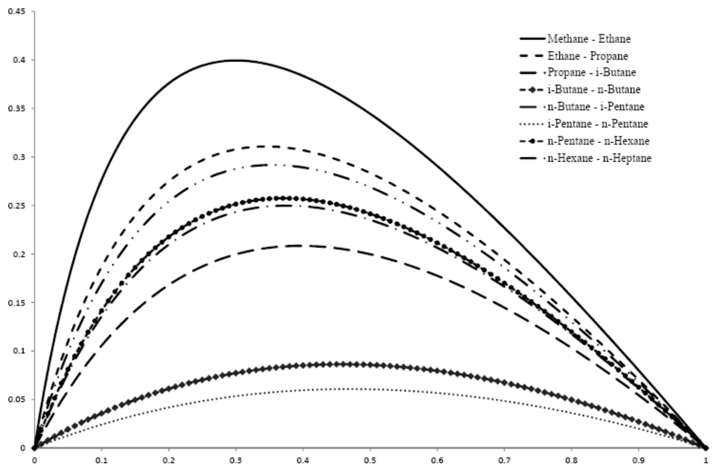

Figure 3: Driving force curve for set of binary component at uniform pressure.

3.4 Energy Comparison

Total energy used to recover every single NGLs fractions for the existing and the new optimal sequences are shown in Table 1. The results show that the maximum of 10.2% energy reduction was able to achieve by changing the sequence suggested by the driving force method.

Table 1: Energy Comparison between Direct-Splitter-Direct sequence and Driving Force sequence for NGLs fractionation process

Distillation Column Unit	Direct-Splitter-Direct Sequence (MW)	Driving Force Sequence (MW)	Percentage Difference (%)
Total Condenser Duty MW)	65.88	58.58	11.09
Total Reboiler Duty (MW)	71.62	64.32	10.19
Total Energy (MW)	137.50	122.9	10.62

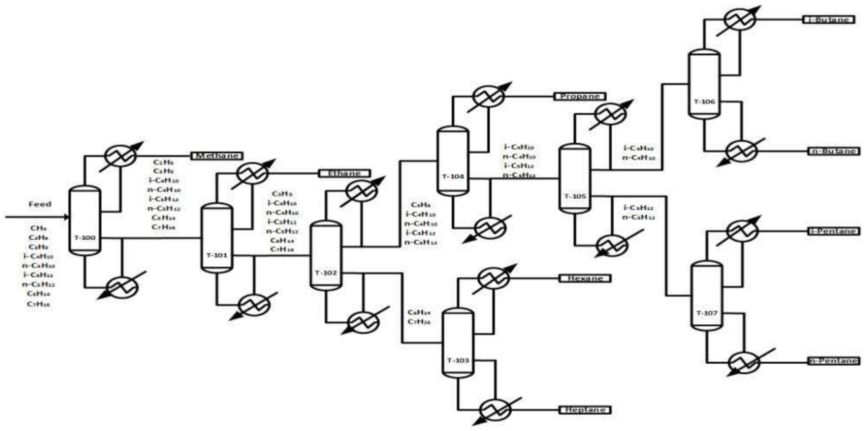

Figure 4: Flow sheet illustrating the existing direct-splitter-direct sequence of NGLs fractionation process using driving force method

4 Conclusion

It can be concluded that, the sequence determined by the driving force method is able to reduce energy used for NGLs fractionation. All of this findings show that the methodology is able to design energy efficient splitters for NGLs fractionation sequence in an easy, practical and systematic manner. The results (see Table 1) show that the maximum of 10.62 % energy reduction was able to achieve by changing the sequence suggested by the driving force method.

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